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Effect of food upon milk, Bulletin, no. 9

New Hampshire Agricultural Experiment Station

NEW HAMPSHIRE
AGRICULTURAL
EXPERIMENT STATION,

HANOVER, N. H.

BULLETIN No. 9.

EFFECT OF FOOD UPON MILK:

(a.) Changes due to Breed and Individual Characteristics.

(b.) Changes due to Other Causes aside from Food.

(c.) Changes due to Changed Food.

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EFFECT OF FOOD UPON THE QUALITY OF MILK.

WHAT IS MILK?

This question is an old one, but nevertheless no complete answer has been given to it, nor can one be given to-day. Certain things are known to be true concerning milk, and from the works of physiologists, chemists and microscopists we are able to give something of an answer to this question. We may study milk in two ways, with the microscope, and with the apparatus of the chemist.

1st. How does milk appear when viewed under the microscope? Not as a simple white fluid as it does to the naked eye, but as a fluid in which are floating countless millions of little spherical particles; these are the *fat globules*, little droplets of pure butter fat. These vary very much in size, both in individuals and among breeds; the average figures resulting from measurements of our four breeds, namely: Jersey, Holstein, Ayrshire and Shorthorn, have been found to be about one eight-thousandth of an inch. If we would get some idea of how small a particle this is, let us remember that such a globule under a microscope magnifying 500 diameters would appear one sixteenth of an inch in diameter, while a common lead pencil magnified the same number of times would appear fifteen feet in diameter; or, if we should desire to lay a row of these little particles of fat across the squared end of the pencil, it would require 2,500 of them, or to cover the entire surface of the pencil end would require 4,900,000 globules.

That the globules vary in size has already been alluded to. Globules are found that are only one forty-thousandth of an inch in diameter, and others one twenty-five-hundredth of an inch.

THE CHEMICAL COMPOSITION OF MILK.

The common method of analyzing milk, separates the sample into five parts, namely: water, fat, caseine, sugar and ash. This composition varies greatly, both among individual animals of the same breed, and also the averages of breeds. I have selected two animals, one a Jersey, the other a Shorthorn, to show the variation of each constituent of the milk, and also have given the average per cent. of fat in the milk of each cow, as well as the fat in the milk of each breed.

COMPOSITION OF MILK.	JERSEY.	SHORTHORN.	AVERAGE OF ALL KINDS OF MILK.
	PER CENT.	PER CENT.	PER CENT.
Water,	84.10	87.00	87.00
Solids,	15.90	13.00	13.00
	100.00	100.00	100.00
Fat,	6.09	3.85	3.75
Caseine,	3.95	3.31	3.50
Sugar,	5.12	5.10	5.00
Ash,	.74	.74	.75
	15.90	13.00	13.00

Richness of milk from four breeds of cows and four individual cows of each breed, at the New Hampshire Experiment Station :

	JERSEY.	AYRSHIRE.	HOLSTEIN.	SHORTHORN.
NO. OF COW.	PER CT. FAT.	PER CT. FAT.	PER CT. FAT.	PER CT. FAT.
1.	5.02	3.81	3.29	4.13
2.	5.08	4.55	3.54	3.50
3.	4.34	4.28	2.85	4.15
4.	6.06	4.48	2.84	3.68
Averages,	5.12	4.28	3.13	3.86

Here we see the greatest variation is in breeds. The difference in averages' amounts to 63 per cent. ; that is, the amount of fat in the Jersey milk is 63 per cent. greater than in the Holstein. The variation between the richest and poorest milk of individual cows in each breed, was as follows : Jersey, 39 per cent. ; Ayrshire, 19 per cent. ; Holstein, 24 per cent. ; Shorthorns, 18 per cent.

What has already been said does not seem to bear much upon the subject, perhaps, but if we are to show how the richness of milk may or may not be changed, we must know what variations are due to breed and what to individuals ; that is, we must fully appreciate the fact that there are wide variations due to these two causes, and we must not conclude, as some are prone to do, that because a herd of *Jerseys*, fed on one kind of food, produce milk which will make a pound of butter from sixteen pounds of milk, and another herd, of *Holsteins*, fed on a radically different food, produce milk of which twenty-five pounds are required for a pound of butter, therefore the *food* of the Jerseys produced richer milk ; it is not the *food* but the *breed*. Our four breeds have been fed practically alike, and the average differences in the fat percentage in their milk is due to the *breed* and not to the *feed*.

Again, we often hear it said: "I have a Jersey cow; she is fed on hay and corn meal. She produces milk of which fifteen pounds will make a pound of butter; my neighbor has a Jersey, but he feeds her ensilage and shorts, and it takes twenty pounds of her milk to make a pound of butter; therefore I believe ensilage makes poor milk." It is needless for me to point out that such an argument is worthless. An inspection of the above table shows us that one of our Jerseys would make a pound of butter from fifteen pounds of milk, while another's milk only gives a pound of butter for twenty-one pounds of milk, and this on the same kind of food. Let me repeat, and emphasize the fact, that *breed* and *individual characteristics* are the two great factors that determine the richness of milk.

PERIOD OF LACTATION.

Another factor which has appreciable influence is the time since calving. The same cow, on the same kind of food, will yield richer milk after ten months of milking than at the end of one month.

A cow that gave milk containing 3.5 per cent. of fat in November and December, 1888, on the same kind of food in May, 1889, gave milk with 3.9 per cent, in August, on pasture feed, 4.16 per cent., and in September 4.23 per cent.

Another cow averaged 3.6 per cent. in December and November, 1888, 3.9 per cent in April, 1889, 4.4 per cent. in May. These are only two instances, but it is a fact well known that most cows do so increase. Now, this being true, we must not too hastily conclude that a given kind of food has caused increased fat in the milk, since it may be that a part or the whole of the observed change is due to a *natural* increase due to length of time in milk and not to food at all.

MORNING'S AND NIGHT'S MILK.

That there is a variation in the richness of the morning's and night's milk of most cows is generally understood, but there are some facts which are brought out by our work that are new, so far as I know, though others may have observed the same thing.

The *morning's* milk, in the case of three cows whose milk has been analyzed night and morning daily for a full year, has been richer than the *night's* milk during the time that the cows were on pasture feed, but when the same cows were put into the barn the reverse was true; that is, the night's milk was the richer. The difference between morning and night's milk is quite marked; thus, during June, July and August a Jersey cow gave milk which averaged as follows:

Morning's milk,	6.26 per cent.,	Average, 6.01 per cent.
Night's milk,	5.75 per cent.,	
Difference,	0.51 per cent., in favor of morning's milk.	

The same cow during January, February and March, gave:

Morning's milk,	5.81 per cent.,	Average, 6.05 per cent.
Night's milk.	6.30 per cent.,	
Difference,	0.49 per cent. in favor of night's milk.	

Other cows give corresponding results, not so marked, perhaps, but nevertheless, we may fairly conclude that either the exercise involved in grazing over a comparatively large pasture, or the heat of the day, or both together, tend to diminish the richness of the milk secreted during the day, while the quiet or coolness of the night tends towards a richer product In winter, however, our cows remain quiet both day and night, not absolutely, of course, but still the exercise during the day is very little as compared with summer; but why the night's milk should so much exceed the morning's is unaccountable unless it may be that the slightly shorter period between milking might in part explain the fact.

I have alluded to this variation because it is one of the *larger variations* which may be brought about in milk, and, certainly, so far as the difference in fat contents of the milk, night and morning, is concerned, it is not due to food, for the same food is concerned in the production of the night's milk and the morning's milk, and the difference of one-half of one per cent. must be due in summer, at least, to other causes than *food* or time of milking, for the periods between milking are equal at that season of the year.

FREQUENCY OF MILKING.

An experiment was conducted with two cows, for the purpose of noting the effect of very frequent milking. A Shorthorn cow was milked every hour, for twenty-four hours, and a sample of each milking was analyzed. At the time of the commencement of the experiment this cow was giving 14.25 pounds of milk daily, in which there was 3.89 per cent. of fat, or .554 pounds of actual fat daily. In twenty-four hours. of hourly milking, she produced 16.25 pounds of milk, in which was 5.27 per cent. of fat, or of total fat, .856 pounds, an increase of fifty-four and one-half per cent in the total fat, in twenty-four hours.

The other cow, a Jersey, produced, previous to the experiment, 10.07 pounds, in which was 6.02 per cent of fat, or .606 pounds. The test was for seventy-two hours. and I will divide it into three daily periods:

	AMOUNT OF MILK.	PER CENT. OF FAT.	ABSOLUTE FAT PER DAY.	GAIN. PER CENT.
1st day,	10.5	7.05	.743	$27\frac{1}{4}$
2nd "	10.6	5.94	.630	4
3rd "	10.9	5.74	.626	$3\frac{1}{3}$
Total,	32.0	18.75	19.99	
Average,	10.6 pounds.	6.24	.666 pounds.	10

Here we have another variation in per cent. of fat and in total fat produced, which is *not due to food.*

In this connection I need only allude to the well known fact that the last milk drawn from the udder is much richer than the first. In the case of the Shorthorn cow that was milked hourly, the first four ounces of milk and the last four ounces of the next full milking after the experiment, were analyzed for fat, with the following results :

First milk, per cent. fat, 1.36.
Last " " 8.04.

The average for the milking was 3.36 per cent.

Thus far we may say that the following circumstances affect the quality of milk :

1st. Breed.
2d. Individual characteristics.
3d. Period of lactation ; (that is, the time since calving.)
4th. Morning's and night's milk.
5th. Frequent milking.
6th. Samples drawn from first milk taken from udder or from strippings.

It may fairly be claimed that *all of these are independent of the food.*

HOW IS MILK FORMED.

Before we approach the relation between food and milk, I wish to touch upon a subject which is the very foundation of all speculation concerning the transformation of food into milk.

How milk is formed no man knows, any more than we can tell how the plant constructs starch from the elements of water and carbonic acid. It is sufficient for us to know that blood goes to the udder, carrying those portions of the food which have been digested and absorbed ; from this blood supply milk results. It was formerly held that the udder acted as a sort of filter, removing from the blood those constituents which, when brought together, formed milk. Looked at from this standpoint the constituents of the milk must exist in the blood as it goes to the udder. Physiologists agree that caseine is not found in the blood, also that milk sugar is not found in the blood ; this being true, it would seem to be a logical conclusion that the udder could not act as a filter, removing the constituents of the milk from the blood, for the apparently good and sufficient reason that these constituents are not in the blood at all. The structure of the udder may possibly aid us in gaining an idea of what is now believed, by the best physiologists, to be the true origin of milk.

Starting at the teat, there is the opening through which the milk is drawn ; following this upwards it leads into a more or less well marked cavity, the " milk reservoir ", this is not always found, innumerable branches or milk ducts lead out from this, dividing and subdividing, until the whole of the gland substance is traversed by small tubes. Opening into these tubes are the true secreting parts ; these are little sacks lined on the inside with cells, which are the true points where milk is formed. The fat globules, says Foster, can be seen to form in these lining cells, and are forced out into the cavity of the little sacks. It is believed that the constituents of the milk, namely: the fat, caseine and sugar are made within these cells, and out of the cell contents, not out of blood at all. The blood brings digested food to the udder, it there nourishes and furnishes material from which to grow these lining cells, and the cells, as a peculiarity of their own, have the power of changing the protoplasm which they contain into milk. The blood that goes to the udder is not different from the blood that goes to sustain and nourish the other parts of the body, and food which is capable of producing a good growth of muscle or bone, or of fattening an animal, or in sheep, of producing a good growth of wool, will, if fed to a cow during her milking period, produce growth in the lining cells of the udder and these will see to it that milk is forthcoming. This theory of milk production is certainly no more difficult to accept than the well known fact that a grafted or budded tree may have two branches originating at the same point, one producing sour fruit, the other sweet, and yet both are nourished by the same sap taken up by the same roots, and necessarily containing the same plant food. The explanation, so far as we are able to give one, is that the character of the cells of which the two grafts are made up and of the fruit after it sets is such that one develops a fruit that is acid, while the other develops a fruit in which the sugar taste predominates. Now, it can not be said that it is the sap, or the food of the tree, but it is a power within the living cells of the plant itself.

The whole of this may be condensed into the following: We feed to supply the blood with substances capable of promoting a rapid growth of the cells which line the udder, and their nourishment is not essentially different from that of any other tissue of the body.

If this is a true and logical conclusion, then it is probable that the notion that one ration is a "butter ration," another a "milk ration," a third a "cheese ration," etc., is largely a delusion, and it is probably true that food which is sufficient in quantity and so proportioned in its parts that it nourishes the body well, will produce normal milk, the quality of which will be chiefly determined by the characteristics of the cow to which it is fed.

FOOD.

We may now ask what food is, and in answer may say that food is any substance which can be digested by an animal and which may contribute to the growth and nourishment of the body.

All food is made up of parts of unlike chemical composition; starch, sugar, oil, fiber and albuminoids are found in varying proportions in our feeding stuffs.

For the purposes of the stock feeder we may put all of the constituents of the various fodders we use into two classes, *albuminoids* and *non-albuminoids*. The former are a class of substances which contain nitrogen; they are of like composition with the caseine or curd of milk and the lean meat of animals, and are important, since this caseine, lean meat, and wool, hair and some other parts of the body must be produced from this part of the food. The non-albuminoids include starch, sugar, oil, fibre, etc. This part of the food can not take the place of the albuminoids, since there is no nitrogen in any of the substances mentioned. In the feeding tables we have given the digestible constituents of all our foods, and there is a great variation in the proportion of albuminoids to non-albuminoids; this ratio is known as the "nutritive ratio," and means simply the number of pounds of starch, sugar and fat, *i. e.*, non-albuminoids to one pound of albuminoids. We are told by the German feeders and investigators that the proper "ratio" for a cow giving milk is 1 : 5.4, or that a cow weighing 1,000 pounds needs daily 2.50 pounds of albuminoids and 13.50 pounds of non-albuminoids; and it is for us in the United States to determine whether this amount and proportion of actual digestible matter is best. We have now seen what milk is, have glanced at the most plausible theory concerning its origin. and have learned that food is composed of unlike parts. It remains for us to see what effects follow from changing the kind or quality of food.

HOW MAY WE EXPECT TO CHANGE THE QUALITY OF MILK?

1st. Can we increase or decrease the per cent. of water?

2d. Can we increase or decrease the per cent. of fat?

There is much misunderstanding concerning the way in which milk. is commonly believed to be changed in richness. Now, if we can increase the per cent. of solids from thirteen per cent. to fourteen per cent., then we have made the milk richer; and yet the relative proportion of fat, caseine and sugar in these solids need not vary. Again the solids may remain unchanged, and, if by some method of feeding, we can increase the per cent. of fat, then, so far as the buttermaker is concerned we have a richer milk; or, again, the solids might increase and the fat in the solids decrease to such an extent that there would be no change in the actual per cent. of fat in the milk. To sum up, there are just two ways in which the per cent. of fat in the milk may be increased: 1st, by decreasing the per cent. of water, the ratio of fat, caseine and sugar in the solids remaining undisturbed; 2d, by increasing the relative amount of fat in the solids, the per cent. of water remaining unchanged. Of course a combination of these two methods might have the same effect. For example, let us assume that we have a cow giving milk like the average composition given on page four, and we will suppose that by some method of feeding it is possible to decrease the water to eighty-six per cent and increase the solids to fourteen per cent. Now we need not have any change in the relative properties of caseine sugar and fat. Under these circumstances the analysis of such a milk would be as in the following table, No. 2, or under the second method we will let the solids and water remain unchanged, but will assume that in some way we can increase the relative amount of fat in the solids, at the same time the other constituent of the solids being reduced as in No. 3 :

	No. 1. AVERAGE MILK.	No. 2. SOLIDS INCREASED.	No. 3. SOLIDS UNCHANGED. FAT INCREASED.
Water,	87.00	86.00	87.00
Solids,	13.00	14.00	13.00
Fat,	3.75	4.03	4.03
Caseine,	3.50	3.77	3.40
Sugar,	5.00	5.38	4.85
Ash,	.75	.82	.72

The percentages composition of the "solids," or water free substance on these three milks, would be as follows :

	No. 1. AVERAGE MILK.	No. 2. SOLIDS INCREASED.	No. 3. SOLIDS UNCHANGED. FAT INCREASED.
Fat,	29.00	29.00	31.00
Caseine,	27.00	27.00	26.15
Sugar,	38.45	38.45	37.30
Ash,	5.55	5.55	5.55
	100.00	100.00	100.00

In the case of No. 1 it would require 24.2 pounds of milk to make one pound of butter, while No. 2 and 3 would each make a pound from 22.5 pounds of milk. It is, of course, possible to combine these two ways and get the same result. In Nos. 1 and 2 it is seen that the gain comes entirely by reducing the water, for the solids are made up of just the same proportion of each constituent. In No. 3 the water is not changed, but the properties of fat *in the solids* is increased from twenty-nine to thirty-one per cent. while the caseine, sugar and ash are reduced. These are assumed cases, but if we are to increase the richness of milk in butter fat, it must be done in the ways indicated.

The following results are given, as they bear more or less directly upon the subject under consideration :

GREEN FOOD.

It is generally believed that green, succulent food is favorable to a large flow of milk, but the quality is supposed to be poor, or, stated in a short way, watery food makes watery milk. Is this so?

When cows go from barn feed to pasture grass in May, they are changed onto very watery food, and it is generally thought that while there is usually a considerable increase in quantity, there is also a decrease in solids in the milk.

During the year from Sept., 1888 to Sept., 1889, the milk of three cows, two Shorthorns and a Jersey, was analyzed daily, night and morning. One of these dried off at about the time of going to pasture, and so I can not give any figures of value on this point from her milk; the other two however were affected as follows:

EFFECT OF PASTURE GRASS ON QUANTITY AND QUALITY OF MILK.

	JERSEY.	SHORTHORN.
Increased Milk,	2.3 pounds daily.	2 pounds daily.
" Fat,	.2 of one per cent.	.05 of one per cent.
" Caseine,	(no change.)	.15 " "
" Solids,	.2 of one per cent.	(no change.)
Decreased Sugar,	(no change.)	.2 of one per cent.

Here we have two ways by which the quality of milk was affected. The Shorthorn's milk was not appreciably enriched, it is true, but, so far as it was affected, there was no change in the per cent. of water and solids, but the fat and caseine together were increased .2 of one per cent., while the sugar was decreased exactly the same amount.

The Jersey milk was not changed in sugar or caseine, but the fat was increased, and to the same extent the per cent. of solids was made more.

On the whole herd numbering about twenty, the milk was increased, while the amount necessary to produce a pound of butter was decreased about 1.5 pounds.

Here we see that succulent food made more milk and better milk.

ENSILAGE.

The substitution of ensilage for dry fodder has, by some writers been characterized as a "polite way to water milk;" is this true?

Two Shorthorn cows gave the following results, when changed from dry fodder to ensilage:

	No. 1.	No. 2.
Increased Milk,	½ lb. daily.	½ lb. daily.
" Solids,	.3 of 1 per cent.	(no change.)
Decreased Sugar,	(no change.)	.17 of 1 per ct. daily.
" Solids,		.07 " " " "
Increased Fat,	.15 of 1 per cent. daily,	.01 " " " "
" Caseine,	.08 " " " "	.20 " " " "

There is no evidence here that ensilage waters the milk ; in fact, the only thing really proven is that the variation is very small ; but, so far as there is any change, the tendency is for ensilage to make more milk and better milk than dry fodder, thus corresponding with pasture feed. In table 1, following, it will be seen that Lot G on ensilage gave more milk, and milk that was richer in all solids, except caseine.

CHANGING THE NUTRITIVE RATIO.

A change of "nutritive ratio" means feeding rations in which the proportion of albuminoids to non-albuminoids is changed. For example, two rations, made up as follows, have been fed :

	RATION, 1 a.	RATION, 7 a.
Ensilage,	44 lbs,	44 lbs.
Hay,	5½ "	5½ "
Corn Meal,		6 "
Middlings,	3 "	3 "
Gluten,	6 "	
Nutritive Ratio,	1 : 5.2	1 : 9

This may be regarded as a wide variation ; the ration 1a is a little richer in albuminoids than the German standard requires, but the 7a combination is an excessive starchy ration. If the character of the food exerts any marked effect on the *quality* of the milk it would seem that these two rations ought to make themselves felt.

At the same time that these two rations were being fed, other rations, intermediate between them, were also fed. Each lot of cows consisted of two, and the lots were alternated, being fed two weeks in each period. The following table shows the results in quantity :

		FIRST PART.		SECOND PART.		
LOT.		NUTRITIVE RATIO OF FOOD.	MILK PRODUCED IN 14 DAYS.	NUTRITIVE RATIO OF FOOD.	MILK PRODUCED IN 14 DAYS.	LOSS DUE TO WIDENING THE RATIO.
1	A.	1 :5.2	660 lbs.	1 :9	598 lbs.	62
	B.	1 :5.2	552	1 :9	497	55
			1212		1095	117
2	C.	1 :5.6	560	1 :8	530	30
	D.	1 :5.6	700	1 :8	635	65
			1260		1165	95
3	G.	Ensilage,	587	Hay,	512	75

The decrease in milk amounts to about 10 per cent. in the first combination, 8 per cent. in the second, and 13 per cent. in the third. Now, how much was the chemical composition varied?

	LOT. A. Jersey and Shorthorn. Average Comp. of Milk.			LOT. B. Jersey and Ayrshire. Average Comp. of Milk.			LOT. C. Shorthorn and Ayrshire. Average Comp. of Milk.			LOT. D. Ayrshire and Holstein. Average Comp. of Milk.			LOT. G. Average Comp. of Milk.		
	With a Nutritive Ratio of 1:5.2.	With a Nutritive Ratio of 1:9.	Gain or Loss.	With Nutritive Ratio 1:5.2.	With Nutritive Ratio 1:9.	Gain or Loss.	With Nutritive Ratio 1:5.6.	With Nutritive Ratio 1:8.	Gain or Loss.	With Nutritive Ratio 1:5.6.	With Nutritive Ratio 1:8.	Gain or Loss.	With Ensilage 1:7.2.	With Hay 1:7.2.	Gain or Loss.
Water.	87.09	87.02		86.15	86.12		87.07	86.89		87.92	87.58		87.26	87.39	
Solids.	12.91	12.98	*.07	13.85	13.88	*.03	12.93	13.11	*.18	12.08	12.42	*.34	12.74	12.61	†.13
Fat.	3.92	3.86	†.06	4.89	4.36	†.53	3.82	4.11	*.29	3.63	3.57	†.06	3.67	3.66	†.01
Caseine.	3.19	3.35	*.16	3.48	3.64	*.16	3.38	3.31	†.09	3.14	3.16	*.02	3.22	3.29	*.07
Sugar.	5.04	5.02	†.02	4.75	5.15	*.40	4.98	4.95	†.03	4 54	4.95	*.41	5.05	4.90	†.15
Ash.	.76	.75	†.01	.73	.73		.75	.74	†.01	.77	.74	†.03	.80	.76	†.04
Solids not fat.	8.99	9.12	*.13	8.96	9.52	*.56	9.11	9.00	†.11	8.45	8.85	*.40	9.07	8.95	†.12
Ratio of caseine to fat.	1:1.23	1:1.15		1:1.40	1:1.20		1:1.13	1:1.24		1:1.15	1:1.13		1:1.14	1:1.11	
Average daily milk yield.	47.1	42.7	†4.4	39.5	35.3	†4.2	40.1	38.1	†2.0	49.9	45.4	†4.5	42.0	36.8	†5.2
Amount of butter which this milk would make.	2.03	1.81	†.22	2.13	1.69	†.44	1.68	1.72	*.04	1.98	1.78	†.20	1.74	1.48	†.26

* Gain. † Loss.

Table one, when averaged for the first four lots, gives us the decrease or increase of each constituent of the milk, due to substituting corn meal for gluten meal, pound for pound ; that is,

CHANGING FROM A NARROW TO A WIDE NUTRITIVE RATIO.

	DECIMAL OF A PER CENT.	
	DECREASE.	INCREASE.
Solids		.155
Fat	.09	
Caseine		.06
Sugar		.19
Ash	.01	
Solids not fat		.245

This table means, that the solids were increased $\frac{155}{1000}$ of one per cent., the fat decreased $\frac{9}{100}$ of one per cent., etc. The quantity of milk was decreased 8.5 per cent., and the quality of butter 10.5 per cent., by the change.

The amount of milk produced by each cow daily, on an average. was :

	LBS.
On gluten, (narrow ratio)	22.07
On corn meal, (wide ratio)	20.2
Loss, (due to wide ratio)	1.87

The amount of butter was :

	LBS.
On gluten, (narrow ratio)	.977
On corn meal, (wide ratio)	.875
Loss, (due to wide ratio)	.102

It is no part of the plan of this *Bulletin* to discuss the matter of cost of foods, or cost of milk and butter, but for the benefit of any who may wish to know, I will say that the average cost of the corn meal rations was $0.161, of the gluten meal $0.171, per day. And with the eight cows under consideration the cost of milk per cwt., with the gluten, was $0.774 ; with the corn meal, $0.797—a difference of $0.023 per cent. in favor of gluten.

THE RATIO OF CASEINE TO FAT.

There has been some very interesting work done by Professors Sanborn, Henry and Roberts, which seems to show that a highly nitrogenous diet, that is, one with a narrow "nutritive ratio," increases the proportion of albuminoids to fat in the dressed pig and sheep; and their conclusions are that the fat may be relatively and materially increased by starchy food, while the lean may be made relatively more plentiful by the nitrogenous food. Now, as milk is the product of growth in cows, we might reasonably expect to find a similar effect when we feed widely differing rations.

EFFECT OF NARROW AND WIDE NUTRITIVE RATIO ON RATIO OF CASEINE TO FAT.

A Shorthorn cow, whose milk was analyzed twice daily, was fed on rations varying from a nutritive ratio of 1 :5.5 to 1 :12.9. The periods were of fourteen days each, but were repeated. In the following table a number of periods are averaged together and the results stated:

No. of periods averaged.	Nutritive ratio.	Ratio of caseine to fat.
4	1 :5.7	1 :1.180
4	1 :7.5	1 :1.175
5	1 :12.3	1 :1.098
3	*1 :5.	1 :1.14
	ANOTHER SHORTHORN COW.	
2	1 :5.8	1 :1.135
3	1 :5.2	1 :1.12
1	1 :5.1	1 :1.16
1	1 :5.1	1 :1.24

*Cow at pasture—nutritive value estimated.

A JERSEY COW.

No. of periods averaged.	Nutritive ratio.	Ratio of caseinf to fat.
3	1 :7.3	1 :1.48
3	1 :6.6	1 :1.52

From table one the following results are taken:

1 :5.4	1 :1.23
1 :8.5	1 :1.18

Thus we see that, without exception, the *starchy* food gives a larger proportion of caseine to fat than the nitrogenous diet, and we must conclude, so far as this work is concerned, that a highly nitrogenous food does not produce a highly nitrogenous milk.

BUTTER AND CHEESE COWS.

There is one point which needs mentioning, namely: The erroneous idea that, as the fat in milk decreases, the caseine increases.

We are told that cows which are giving milk poor in fat, and are therefore poor butter cows, are great cheese cows; and we are asked to believe that when the per cent. of fat is low the caseine is high. The following average results show the variation between Jerseys and Shorthorns:

		SOLIDS. PER CT.	FAT. PER CT.	CASEINE. PER CT.	SUGAR. PER CT.	ASH. PER CT.
Jersey,		15.75	6	4	5.5	75
Shorthorns,	1	12.25	3.75	3	4.8	70
	2	13.00	4.00	3.25	5.	75

It will be found that a high per cent. of fat and a high per cent. of caseine go together, and a milk rich in fat is not only a good milk for butter but also a good milk for cheese, while the reverse is also true.

And, now, in conclusion, let me say that these results which I have given are fairly representative of other results which we have on hand, and I feel warranted in saying that a given animal by heredity is so constituted that she will give a milk of certain average composition; by judicious or injudicious feeding the amount of milk daily may be very largely varied, but the quality of the product will be chiefly determined by the individuality of the cow. We may fertilize the soil around our grafted apple tree and cause it to produce double the amount of fruit that it would have produced uncared for, but we shall never change the Baldwin apple into a Pound Sweeting, or the Crab apple into a Pippin; the kind of apple is determined by the character of the tree, the amount by the character of the food; so of the cow. A Shorthorn cow can never, by feeding, be changed into a Jersey, and the man who starts out to increase the fat in milk by simply changing the food has, in my opinion, a very difficult task to perform. Slight variations are always cropping out. whether we change the food or not, but changes of per cent. of fat, of any considerable amount, do not appear to trace to food influence, so long as the food is reasonably well proportioned and sufficient in quantity.

Quantity is the result of food influence. Quality is the result of the make-up of the animal.

G. H. WHITCHER, *Director*.